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Natural Rubber Latex-Modified Concrete with Bottom Ash for Sustainable Rigid Pavements

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Abstract

This article investigates the viability of using natural rubber latex (NRL)-modified concrete with bottom ash (BA) as a partial replacement for river sand in sustainable rigid pavements. Concrete mixes with 10% and 20% BA replacement ratios and varying NRL dosages (0%, 1.0%, 1.5%, and 2.0% by weight of cement) were prepared and evaluated for their mechanical and microstructural characteristics. Results showed that BA substitution decreased the compressive strength of concrete. However, the addition of NRL at an optimal dosage of 1.0% significantly improved both the compressive and flexural strengths. The 10%BA+1.0%NRL and 20%BA+1.0%NRL mixes exhibited mechanical properties surpassing the control mix and meeting the minimum requirements for rigid pavement materials. However, excessive NRL content (1.5% and 2.0%) led to a reduction in mechanical strength. Scanning electron microscopy analysis exhibited a denser and more compact matrix in NRL-modified BA concrete, with NRL films enhancing the interfacial bonding and crack-bridging mechanism. Nonetheless, excessive NRL content resulted in the formation of abundant and thicker NRL films, which disrupted the continuity of the cement matrix and created weak zones. X-ray diffraction analysis confirmed the existence of crucial crystalline phases and their optimal balance in the 20%BA+1.0%NRL mix, contributing to its superior performance. Mixes with excessive NRL contents exhibited lower intensities of quartz, calcite, and portlandite peaks, indicating a disturbance in the proper formation and growth of essential crystalline phases. The findings demonstrated the potential of NRL-modified BA concrete as an eco-friendly and high-performance alternative for sustainable rigid pavements when using an optimal NRL dosage, promoting the employment of waste resources and reducing the environmental impact of the construction industry.

Keywords: Bottom Ash; Natural Rubber Latex; Sustainable Concrete Pavement; Microstructural Analysis; Compressive Strength; Flexural Strength.